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(54) CONTINUOUSLY SMOOTH TRANSMISSION

STUFENLOS UND WEICH REGELBARES GETRIEBE

TRANSMISSION A VARIATIONS DOUCES EN CONTINU

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(56) References cited:
EP-A- 0 226 844 DE-A- 3 302 546
SU-A- 673 480 US-A- 1 349 924
US-A- 3 637 036 US-A- 3 892 283
US-A- 3 990 235 US-A- 4 140 196
US-A- 4 421 217 US-A- 4 441 573
US-A- 5 062 498 US-A- 5 201 570

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MOTOREN" ATZ AUTOMOBILTECHNISCHE
ZEITSCHRIFT, vol. 94, no. 4, 1 April 1992, pages
186-188, 190, 194, 196 - 197, XP000264694

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Description**BACKGROUND OF THE INVENTION****Field of the Invention:**

[0001] The field of the invention is in motor vehicle transmissions providing increased fuel energy utilization efficiency.

The Prior Art:

[0002] Conventional transmissions used in motor vehicles transmit torque from the engine to the wheels by two means: (1) the predominant torque transfer is "pass through", i.e., in response to the driver's command for more power, the flow rate of fuel is increased to the engine, the engine's torque is increased and the increased torque is "passed through" to the wheels (see Mode 1 for a typical engine torque map - line "X" shown in Fig. 1); and (2) when the driver's command for more power exceeds what the engine can supply at its initial speed, the driver must shift the transmission to a lower gear (either manually or by triggering the shift in an "automatic" transmission) to increase the engine's speed (see Mode 2 - line "Y" in Fig. 1, for example). Since power to the wheels at a given vehicle speed is proportional to engine torque times engine speed, power to the wheels is increased by either increasing engine torque (fuel flow rate at a given engine speed) and/or by increasing engine speed. There are two principal disadvantages of such transmissions: (1) the engine is usually operating in Mode 1 and thus supplies torque at an average efficiency much less than the optimum available (e.g., in Fig. 1 point A represents an average value while point B represents the optimum available efficiency at that speed); and (2) when a change of gear is needed, there is an interruption in the supply of torque to the wheels, manifested as a "jerk". Automatic transmissions smooth this "jerk" through a torque converter; however, increased inefficiency is the result.

[0003] Much work has been devoted to replacing conventional transmissions and their inherent disadvantages. This work has focused largely on continuously variable transmissions (CVTs). Ideally, with a CVT an engine would operate along line "Z", the optimum efficiency line as shown on Fig. 1. CVT designs include mechanical (e.g., variable ratio pulleys), electric (an electric generator driven by the engine "powers" an electric motor connecting the wheels -- modern train locomotives utilize this design) and hydraulic which operates much like the electric design. These designs offer some improvements but still rely on Mode 1 (line "X" in Fig. 1 - increased fuel rate at a given speed or, more generally when speed is changing, increased fuel rate per combustion event), as the means of increasing engine speed to increase power to the wheels. However, operation along the optimum torque curve shown as line "Z"

in Fig. 1, leaves little remaining torque available above this optimum for rapidly increasing the speed of the engine (i.e., accelerating the rotating mass of the engine while overcoming increased friction) to quickly respond to the driver's command for increased power to the wheels. Rapid power response is a critical vehicle performance characteristic from a driver/customer's perspective.

[0004] There are two options currently recognized as improving the response of a CVT. The first option initially reduces the torque available to the wheels and applies this torque to accelerating the engine to the needed increased speed. However, this first option is commercially unacceptable because it results, not just in hesitation, but in an actual loss of power to the wheels, completely contrary to the driver's command for more. The second option reduces the standard operating curve downward from optimum so that mere torque is available for Mode 1 function (See line "W" in Fig. 1), therefore resulting in a further efficiency trade-off while still not achieving the power response of conventional transmissions that can fully utilize both Mode 1 and Mode 2.

[0005] A drive train for a vehicle, as defined in the pre-characterizing portion of claim 1, is known from US-A-3 892 283.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an object of the present invention to provide a third option that not only totally solves the power response constraint of conventional CVT designs, but also does so without the necessity of increasing engine torque (Mode 1) for the needed engine speed increase, and without the associated inefficiencies.

[0007] Another object is to provide a power train for a vehicle which reduces emissions of NO_x, CO₂ and other pollutants from motor vehicles.

[0008] Still another object of the present invention is to provide a continuously variable transmission which both: (1) gives a continuous, smooth and rapid response to a driver command for an increase in power to the wheels; and (2) does so without the necessity of utilizing increased engine torque (and thus fuel consumption per engine combustion cycle) to increase engine speed, such increased engine speed being required to satisfy the new, increased power level required at the wheels.

[0009] Yet another object of the present invention is to satisfy the above objectives while allowing for engine operation maintained at or near the optimum efficiency curve for the engine.

[0010] Still another object is to provide the above functions by initially reducing the power supplied by the engine to the wheels, while still providing increased power to the wheels in response to the driver's command.

[0011] A further object is to utilize multiple drive motors and, for hybrid applications, multiple generators (pumps), to maximize drive train efficiency.

[0012] With a view toward realization of the above objects, the present invention provides a drive train for a vehicle which has front and rear wheels as defined in claim 1.

[0013] An electronic control unit (ECU) receives signals representative of the vehicle speed, accumulator pressure and power demanded by the driver and outputs control signals to the pump controller and the motor controller to govern the displacements thereof. In an embodiment employing plural fluidic motors, the ECU also functions to select for operation a fluidic motor displacement or combination of different displacements for different motors best suited for the detected vehicle power demand.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a graph of percentage of maximum engine torque versus engine speed for a typical engine, with curves showing percent fuel efficiency; Fig. 2 is a schematic diagram of a drive train in accordance with a first embodiment of the present invention; Fig. 3 is a schematic diagram of a second embodiment of the drive train of the present invention; Fig. 4 is a graph of the swash angle of a typical pump or motor, which may be utilized as one component of the drive train of the present invention, versus operating pressure; with curves showing percent efficiency; Fig. 5 is a schematic diagram of a third embodiment of the drive train of the present invention; Fig. 6 is a schematic diagram of a fourth embodiment of the drive train of the present invention; Fig. 7 is a schematic diagram of a fifth embodiment of the drive train; Fig. 8 is schematic diagram of a sixth embodiment of the drive train of the present invention; and Fig. 9 is a schematic diagram of the electronic control unit of the present invention showing input signals and output signals.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Fig. 2 shows a first preferred embodiment wherein a hydraulic CVT is combined with an accumulator, to provide a hydraulic, continuously smooth transmission (hereinafter "CST"). An engine 1 delivers power to a hydraulic pump 2 which, in turn, delivers a flow of pressurized hydraulic fluid through line 3 to a hydraulic motor 4. The hydraulic motor 4 transforms the hydraulic power to torque which is supplied to the wheels 5. An accumulator 6 is also connected to line 3 and serves as an additional source of supply of a flow of pressurized hydraulic fluid to the hydraulic motor 4. The accumulator

6 contains a volume of gas and, as hydraulic fluid is pumped into accumulator 6, the pressure of the gas increases and energy is stored. When this stored energy is needed, the hydraulic fluid is allowed to exit the accumulator 6 and supply power to the hydraulic motor 4. Since the exiting flow of hydraulic fluid from the accumulator 6 can be at a very high rate, the accumulator may be sized to store only a small quantity of energy, and this energy may be supplied in a very short period of time. Therefore, the system may be considered a high power device. A low pressure hydraulic fluid reservoir 7 supplies fluid when accumulator 6 is being charged, and stores fluid when accumulator 6 is supplying power to the hydraulic motor.

[0016] Referring again to Fig. 1, if a vehicle's engine is operating at point C and the driver issues a command for power to the wheels corresponding to point D, i.e., depresses the accelerator pedal 26 (Fig. 2), the displacement of the hydraulic motor 4 is increased by motor controller 22 to increase power to the wheels 5 to the level corresponding to point D in Fig. 1. The greatly increased flow associated with the increased motor displacement can not be quickly supplied by the engine 1 (Fig. 2) until its speed is increased (the problem previously described) and, therefore, accumulator 6 supplies the increased hydraulic fluid flow while the engine speed is increasing. Thus, the CST delivers almost instantaneous response to the driver's request for power to the wheels while maintaining the optimum engine operating characteristics, i.e. while allowing the engine to continue running at peak efficiency. The accumulator 6 can be small, only large enough to "fill in" hydraulic fluid flow while the engine speed changes (usually less than five gallons and probably for most applications closer to one or two gallons).

[0017] In this preferred embodiment the pressure in accumulator 6 is monitored by a pressure sensor 30. The pressure sensor 30 and the accelerator pedal position sensor 28 (or a throttle position sensor) send signals to an ECU 32 (see Fig. 9) which in turn sends output signals for control of pump controller 20, motor controller 22 and fuel supply 24. Thus, the change in the pedal position detected by sensor 28 is correlated with the pressure of accumulator 6 detected by pressure sensor 30 to determine a new displacement setting for pump 2 and a signal is sent from ECU 32 to controller 22 to reset the displacement of motor 4 to the new value. An increase in the displacement of motor 4 (when an increased pedal depression is sensed) will result in a drop in the system pressure and in accumulator 6 and, accordingly, the ECU 32 sends a signal to pump controller 20 to decrease the displacement of pump 2 in accordance with the drop in pressure so that the speed of engine 1 will rapidly increase corresponding to the new power demand. When engine 1 reaches the appropriate speed, the ECU 32 sends a signal to pump controller 20 to increase the displacement of pump 2, satisfying the fluid power requirement and regaining the system set-

point pressure.

[0018] The engine speed increase may be accomplished by one of or a combination of several means. The engine will automatically adjust to a drop in system pressure by increasing speed, thereby maintaining a substantially constant torque output. However, perhaps the most cost-effective means of increasing engine speed is to reduce the displacement of pump 2 by controller 20. The combination of the reduced pressure of the system associated with the increased flow through the motor 4 and the reduced displacement of pump 2 allows the engine output power to be shifted more to accelerating the engine. The power supplied to the system from engine 1 is directly proportional to the pump 2 displacement and system pressure. A similar cost-effective means of increasing the engine speed would be an engine "starter" motor (either electric or hydraulic) which, in combination with reduced system pressure, would rapidly accelerate the engine to the new, needed speed. Of course, the traditional means of increasing engine speed by increasing fuel rate (fuel quantity per combustion event) via 24 (Mode 1) could still be used, but would no longer be required.

[0019] Power reduction, e.g., going from point D to point C in Fig. 1, is handled in a similar manner as power increases except for one important difference. As the displacement of motor 4 (Fig. 2) is reduced, system pressure increases which inherently "drives" the speed of the engine to the required, new lower level. There is, of course, no power response performance requirement for decreasing power demands.

[0020] In the subject invention the accumulator may be replaced with an equivalent high power device, e.g., an electric ultracapacitor in an electric drive transmission.

[0021] Fig. 3 illustrates a second preferred embodiment of the invention which is a variation of the embodiment described in Fig. 2. This second embodiment incorporates the concept of utilizing more than one hydraulic motor to optimize the efficiency of power delivery to the wheels, taking into consideration the extremely wide range of speed and power required at the wheels of motor vehicles. While a large motor is needed for rapid acceleration of the vehicle, such a large motor will not operate efficiently at the more common light accelerations and cruising modes of vehicle driving. Fig. 4 shows percent efficiency on the operating map of a typical large hydraulic motor at a speed that would be geared to correspond to, for example, 50 miles per hour vehicle speed. Point A corresponds to the power level that might be required for a rapid passing maneuver while point B corresponds to a typical cruising road load. It is clear that in order to be able to satisfy the high power demand associated with a rapid acceleration, that the more common and thus highest energy consuming modes like point B would not be satisfied with highest efficiency from a single motor. Therefore, the variation shown in Fig. 3 allows the motor displacement control system to

pick, from among motors 4, 4' and 4", responsive to driver power demand detected by accelerator pedal position sensor 28 and vehicle speed detected by speed sensor 33, that motor (or motors) having the size and displacement that most closely corresponds to the highest efficiency for the detected vehicle speed and power demand. The choice of the number of motors is based on an efficiency versus cost trade-off analysis.

[0022] The use of multiple motors also allows low-cost direct wheel drives and low-cost 4-wheel direct drive. Individual motors can power each wheel (Fig. 6), or direct wheel drive and differential drive can be combined (Fig. 5). Thus, the embodiment of Fig. 5 includes motors 4, 4' and 4" and motor controllers 22, 22' and 22", while the embodiment of Fig. 6 includes motors 4, 4', 4" and 4"" and motor controller 22, 22', 22" and 22"".

[0023] Fig. 7 illustrates the major components of a fifth embodiment. Fig. 7 shows the CST integrated into a hydraulic hybrid propulsion system which incorporates regenerative braking in an efficient and low cost manner. The hydraulic motors 4, 4' and 4" can easily be operated as pumps by reversing the flow of hydraulic fluid to pump fluid from the low pressure reservoir 7 to the second accumulator 8, through flow control valve 9, thus recovering kinetic energy when braking the vehicle and storing it in accumulator 8 for later re-use, for example, for high power demands such as accelerations. Accumulator 8 is sized to be sufficient to store a full braking event plus whatever reserve is desired for further load-leveling and reduction in the size of engine 1. A variation on this embodiment would be the combination of the two accumulators into a single unit.

[0024] Fig. 8 illustrates a sixth embodiment which adds a second engine 10 and pump 11 for a trailer-towing option and/or to allow yet another reduction in size of engine 1. The closer engine 1 can be sized to the average power demand of the vehicle (e.g., 10 horsepower) the more efficient on average and lower cost it will be.

[0025] The present invention allows a conventional vehicle to be fitted with a significantly smaller engine (e.g., 20-40% smaller) while still maintaining the same vehicle performance (i.e., acceleration and responsiveness) because it can always apply the maximum torque producible by the engine to the wheels as compared to a much lower, average value associated with conventional, limited gear transmissions.

[0026] The present invention is especially well suited for hybrid vehicle applications (i.e., vehicles which have two or more power supplies available for powering the vehicle). It has all the advantages of the conventional vehicle application, plus it allows the primary power supply to be sized even closer to the average power demand of the vehicle (as compared to the peak power demand required with a conventional vehicle), extracting much greater efficiency gains while maintaining the performance characteristics of a much larger engine (e.g., 20 horsepower rather than 120 horsepower).

[0027] The present invention allows operation at or near the maximum efficiency of the engine by causing the engine to supply the needed power through a rapid increase in speed and allows even a small engine to follow the torque demand of the driver through a rapid change in engine speed without hesitation or jerk in the transition to increased torque at the wheels, while not requiring an increase in fuel rate per combustion event. This feature further allows the use of a much simpler and therefore much lower cost engine fuel supply system wherein a constant or near constant quantity of fuel is supplied for each combustion event.

[0028] Thus, the present invention provides a continuously variable transmission (CVT) that is unique in its ability to transition to a greatly increased torque to the wheels without experiencing the conventional hesitation and/or jerk associated with the sudden engine speed change of "down shifting," experienced both in mechanical fixed gear "standard" transmissions and in conventional "automatic" transmissions.

[0029] The invention may be embodied in other specific forms without departing from the essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

[0030] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. A drive train for a vehicle having front and rear wheels (5), comprising:

at least one fluidic motor (4), having an inlet and an outlet, driving at least one of the wheels (5);
 at least one pump (2) producing a flow of hydraulic fluid to drive the fluidic motor (4), the pump (2) having an outlet connected by first conduit means (3) to the inlet of the fluidic motor (4) and an inlet connected by second conduit means to the outlet of the fluidic motor (4);
 at least one engine (1) driving the pump (2) at a variable speed;
 a fluid accumulator (6) in fluid communication with the first conduit means (3) and containing pressurized gas in a gas space and a quantity of the hydraulic fluid;
 at least one fluid reservoir (7) in fluid commu-

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nication with the second conduit means;
 power demand sensing means (28) sensing a power demand by a driver of the vehicle for acceleration or deceleration of the vehicle;
 a pressure detector (30) detecting pressure within the accumulator (6) and for generating a pressure signal representative of the detected pressure;
 a motor controller (22); and
 a pump controller (20), characterized in that said motor controller (22) controls displacement of the fluidic motor (4) responsive to the sensed power demand and the pressure signal; and in that
 said pump controller (20) reduces displacement of the pump (2) responsive to a drop in the detected pressure indicated by the pressure signal, thereby increasing the speed of the engine (1), and for increasing displacement of the pump (2) when the engine speed increases to a predetermined value.

2. A drive train in accordance with claim 1 comprising:

a plurality of fluidic motors (4, 4', 4'') connected in parallel, each having a different capacity and each having an inlet connected to the first conduit means (3) and an outlet connected to the second conduit means;

vehicle speed sensor means (33) for detecting vehicle speed;
 plural motor controllers (22, 22', 22''), each motor controller (22, 22', 22'') controlling displacement of one of the plurality of fluidic motors (4, 4', 4''); and

computer means (32) for receiving signals from the power demand sensing means (28), the pressure detector (30) and the vehicle speed sensor (33), for selecting the displacement of at least one of the fluidic motors (4, 4', 4'') in accordance with received signals and for sending a control signal to the motor controller (22, 22', 22'') associated with the selected fluidic motor (4, 4', 4'') for operation in accordance with the sensed power demand and for sending a control signal to the pump controller (20) for changing displacement of the pump (2) responsive to the pressure signal (Fig. 3).

3. A drive train in accordance with claim 1 wherein the fluidic motor (4) drives a pair of the wheels (5) and wherein the drive train further comprises second and third fluidic motors (4', 4''), each of the second and third fluidic motors (4', 4'') driving a wheel (5) other than the pair of wheels (5), and plural motor controllers (22', 22''), each motor controller (22', 22'') controlling one of the fluidic motors (4', 4'') responsive to the sensed power demand (Fig. 5).

4. A drive train in accordance with claim 1 further comprising second, third and fourth fluidic motors (4', 4'', 4'''), each of the fluidic motors (4', 4'', 4''') driving one of the wheels (5), and a plurality of motor controllers (22', 22'', 22'''), each of the motor controllers (22', 22'', 22''') controlling displacement of one of the fluidic motors (4', 4'', 4''') responsive to the sensed power demand (Fig. 6). 5

5. A drive train in accordance with claim 1 further comprising a second pump (11) and a second engine (10) for driving the second pump (11), the second pump (11) having an outlet in fluid communication with the first conduit means (3) and an inlet in fluid communication with a second fluid reservoir, the engine (1) being sized to provide the average power demanded of the vehicle at high efficiency and the second engine (10) being of a substantially greater size than the engine (1) (Fig. 8). 10 15

6. A method for operating a hybrid vehicle having at least one combustion engine (1) and a drive train as defined in claim 1, the method comprising:

- detecting speed of the engine (1); 20
- detecting fluid pressure within the accumulator (6);
- sensing power demand on the vehicle;
- changing displacement of the fluidic motor (4) responsive to the sensed power demand and the detected fluid pressure to meet the power demand and to maintain at least a minimum pressure with the accumulator (6); and
- controlling displacement of the pump (2), responsive to the detected pressure, to maintain the detected engine speed within a range predetermined based on engine efficiency. 25 30 35

Patentansprüche 40

1. Ein Antriebsstrang für ein Fahrzeug, das über Vorder- und Hinterräder (5) verfüge und der folgendes umfasst:

mindestens einen Fluidmotor (4), der über einen Einlass und einen Auslass verfügt und der mindestens eines der Räder (5) antreibt; 45

mindestens eine Pumpe (2), die eine Strömung eines Hydraulikfluids erzeugt, um den Fluidmotor (4) anzutreiben, wobei die Pumpe (2) einen Auslass hat, der durch erste Leitungsmittel (3) mit dem Einlass des Fluidmotors (4) verbunden ist, und einen Einlass hat, der durch ein zweites Leitungsmittel mit dem Auslass des Fluidmotors (4) verbunden ist; 50

mindestens einen Motor (1), der die Pumpe (2) mit einer veränderlichen Geschwindigkeit an- treibt; 55

einen Fluidakkumulator (6), der mit dem ersten Leitungsmittel (3) in Fluidverbindung steht und der Druckgas in einem Gasraum und eine Menge an Hydraulikfluid enthält;

mindestens einen Fluidbehälter (7), der mit dem zweiten Leitungsmittel in Fluidverbindung steht;

ein Leistungsbedarf-Sensormittel (28), das einen Leistungsbedarf eines Fahrzeugführers abtastet, um das Fahrzeug zu beschleunigen oder zu verlangsamen;

einen Druckdetektor (30), der den Druck innerhalb des Akkumulators (6) erfasst und ein Drucksignal erzeugt, das den erfassten Druck darstellt,

einen Motorregler (22); und

einen Pumpenregler (20), dadurch gekennzeichnet, dass

der Motorregler (22) als Reaktion auf den abgetasteten Leistungsbedarf und das Drucksignal die Verdrängung des Fluidmotors (4) steuert; und dadurch, dass

der Pumpenregler (20) die Verdrängung der Pumpe (2) als Reaktion auf einen Abfall im erfassten Druck reduziert, der vom Drucksignal erfasst wird, wodurch die Motordrehzahl (1) erhöht wird, und um die Verdrängung der Pumpe (2) zu erhöhen, wenn die Motordrehzahl auf einen vorbestimmten Wert steigt.

2. Ein Antriebsstrang gemäß Anspruch 1, der folgendes umfasst:

eine Mehrzahl an Fluidmotoren (4, 4', 4''), die parallel verbunden sind und jeweils eine andere Kapazität haben und jeweils einen mit dem ersten Leitungsmittel (3) verbundenen Einlass und einen mit dem zweiten Leitungsmittel verbundenen Auslass haben;

ein Fahrzeuggeschwindigkeits-Sensormittel (33), um die Fahrzeuggeschwindigkeit zu erfassen;

mehrere Motorregler (22, 22', 22''), wobei jeder Motorregler (22, 22', 22'') die Verdrängung von einem der Mehrzahl an Fluidmotoren (4, 4', 4'') steuert; und

ein Computermittel (32) zum Empfangen der Signale vor Leistungsbedarf-Sensormittel (28), vom Druckdetektor (30) und vom Fahrzeuggeschwindigkeits-Sensor (33), damit die Verdrängung von mindestens einem der Fluidmotoren (4, 4', 4'') in Übereinstimmung mit den empfangenen Signalen ausgewählt wird und damit an den mit dem ausgewählten Fluidmotor (4, 4', 4'') verknüpften Motorregler (22, 22', 22'') ein Steuersignal für den Betrieb in Übereinstimmung mit dem abgetasteten Leistungsbedarf

übertragen wird, und damit ein Steuersignal an den Pumpenregler (20) übertragen wird, um als Reaktion auf das Drucksignal die Verdrängung der Pumpe (2) zu ändern (Fig. 3).

3. Ein Antriebsstrang gemäß Anspruch 1, worin der Fluidmotor (4) ein Radpaar (5) antreibt und worin der Antriebsstrang weiterhin einen zweiten und dritten Fluidmotor (4', 4'') umfasst, wobei der zweite und der dritte Fluidmotor (4', 4'') jeweils ein Rad (5) antreiben, das nicht das Radpaar (5) ist, und mehrere Motorregler (22', 22'') umfasst, wobei jeder Motorregler (22', 22'') einen der Fluidmotoren (4', 4'') als Reaktion auf den abgetasteten Leistungsbedarf steuert (Fig. 5). 5

4. Ein Antriebsstrang gemäß Anspruch 1, der weiterhin einen zweiten, dritten und vierten Fluidmotor (4', 4'', 4''') umfasst, wobei jeder Fluidmotor (4', 4'', 4''') eines der Räder (5) antreibt, und eine Mehrzahl an Motorreglern (22', 22'', 22''') umfasst, wobei jeder der Motorregler (22', 22'', 22''') die Verdrängung von einem der Fluidmotoren (4', 4'', 4''') als Reaktion auf den abgetasteten Leistungsbedarf steuert (Fig. 6). 10

5. Ein Antriebsstrang gemäß Anspruch 1, der weiterhin eine zweite Pumpe (11) und einen zweiten Motor (10) zum Antreiben der zweiten Pumpe (11) umfasst, wobei die zweite Pumpe (11) einen mit dem ersten Leitungsmittel (3) in Fluidverbindung stehenden Auslass und einen mit einem zweiten Fluidbehälter in Fluidverbindung stehenden Einlass hat, wobei der Motor (1) so dimensioniert ist, um die vom Fahrzeug angeforderte durchschnittliche Leistung bei hohem Wirkungsgrad bereitzustellen, und wobei der zweite Motor (10) im wesentlichen größer ist als der Motor (1) (Fig. 8). 15

6. Ein Verfahren zum Betreiben eines Hybridfahrzeugs, das mindestens einen Verbrennungsmotor (1) hat, und einen Antriebsstrang, wie im Anspruch 1 definiert, wobei das Verfahren folgendes umfasst:

- das Erfassen der Drehzahl des Motors (1);
- das Erfassen des Fluiddrucks innerhalb des Akkumulators (6);
- das Abtasten des Fahrzeug-Leistungsbedarfs;
- das Ändern der Verdrängung des Fluidmotors (4) als Reaktion auf den abgetasteten Leistungsbedarf und des erfassten Fluiddrucks, um dem Leistungsbedarf zu befriedigen und um zumindest einen Mindestdruck mit dem Akkumulator (6) aufrechtzuerhalten; und
- das Steuern der Verdrängung der Pumpe (2) als Reaktion auf den erfassten Druck, um auf der Grundlage des Motorwirkungsgrads die erfasste Motordrehzahl innerhalb eines vorbestimmten Bereichs zu halten.

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Revendications

1. Transmission pour un véhicule ayant des roues avant et arrière (5), comportant :

- au moins un premier moteur fluidique (4), ayant une entrée et une sortie, entraînant au moins une des roues (5);
- au moins une pompe (2) produisant un écoulement de fluide hydraulique pour entraîner le moteur fluidique (4), la pompe (2) ayant une sortie connectée par l'intermédiaire de premiers moyens formant conduit (3) à l'entrée du moteur fluidique (4), et une entrée connectée par l'intermédiaire de seconds moyens formant conduit à la sortie du moteur fluidique (4);
- au moins un moteur (1) entraînant la pompe à une vitesse variable;
- un accumulateur de fluide (6) en communication de fluide avec les premiers moyens formant conduit (3) et contenant du gaz sous pression dans un espace de gaz et une quantité du fluide hydraulique;
- au moins un premier réservoir de fluide (7) en communication de fluide avec les seconds moyens formant conduit;
- des moyens de détection de demande de puissance (28) détectant une demande de puissance du conducteur du véhicule pour une accélération ou une décélération du véhicule;
- un détecteur de pression (30) détectant la pression à l'intérieur de l'accumulateur (6), et pour créer un signal de pression représentatif de la pression détectée;
- un régulateur de moteur (22); et
- un régulateur de pompe (20), caractérisée en ce que

le dit régulateur de moteur (22) commande la cylindrée du moteur fluidique (4) en réponse à la demande de puissance et au signal de puissance détectés; et en ce que

le dit régulateur de pompe (20) réduit la cylindrée de la pompe (2) en réponse à une chute de la pression détectée indiquée par le signal de pression, en faisant ainsi augmenter la vitesse du moteur (1), et pour augmenter la cylindrée de la pompe (2) lorsque la vitesse du moteur augmente jusqu'à une valeur prédéterminée.

2. Transmission selon la revendication 1, comportant :

- une pluralité de moteurs fluidiques (4, 4', 4'') connectés en parallèle, chacun ayant une capacité différente et chacun ayant une entrée connectée aux premiers moyens formant conduit (3) et une sortie connectée aux seconds moyens formant conduit;

des moyens capteurs de vitesse de véhicule (33) pour détecter la vitesse du véhicule; plusieurs régulateurs de moteur (22, 22', 22''), chaque régulateur de moteur (22, 22', 22'') commandant la cylindrée d'un moteur parmi la pluralité de moteurs fluidiques (4, 4', 4''); et des moyens informatiques (32) pour recevoir des signaux des moyens de détection de demande de puissance (28), du détecteur de pression (30) et du capteur de vitesse de véhicule (33), pour sélectionner la cylindrée d'au moins un des moteurs fluidiques (4, 4', 4'') conformément aux signaux reçus, et pour envoyer un signal de commande vers le régulateur de moteur (22, 22', 22'') associé au moteur fluidique sélectionné (4, 4', 4'') pour fonctionner conformément à la demande de puissance détectée, et pour envoyer un signal de commande vers le régulateur de pompe (20) pour modifier la cylindrée de la pompe (2) en réponse au signal de pression (figure 3). 5

3. Transmission selon la revendication 1, dans laquelle le moteur fluidique (4) entraîne une paire de roues (5), et dans laquelle la transmission comporte de plus des deuxième et troisième moteurs fluidiques (4', 4''), chacun des deuxième et troisième moteurs fluidiques (4', 4'') entraînant une roue (5) autre que la paire de roues (5), et plusieurs régulateurs de moteur (22', 22''), chaque régulateur de moteur (22', 22'') commandant un des moteurs fluidiques (4', 4'') en réponse à la demande de puissance détectée (figure 5). 10

4. Transmission selon la revendication 1, comportant de plus des deuxième, troisième et quatrième moteurs fluidiques (4', 4'', 4'''), chacun des moteurs fluidiques (4', 4'', 4''') entraînant une des roues (5), et une pluralité de régulateurs de moteur (22', 22'', 22'''), chacun des régulateurs de moteur (22', 22'', 22''') commandant la cylindrée d'un des moteurs fluidiques (4', 4'', 4''') en réponse à la demande de puissance détectée (figure 6). 15

5. Transmission selon la revendication 1, comportant de plus une seconde pompe (11) et un second moteur (10) pour entraîner la seconde pompe (11), la seconde pompe (11) ayant une sortie en communication de fluide avec les premiers moyens formant conduit (3), et une entrée en communication de fluide avec un second réservoir de fluide, le moteur (1) étant dimensionné pour fournir la puissance moyenne demandée du véhicule à un rendement élevé, et le second moteur (10) ayant une taille sensiblement plus grande que le moteur (1) (figure 8). 20

6. Procédé pour faire fonctionner un véhicule hybride ayant au moins un moteur à combustion (1) et une transmission telle que définie dans la revendication 1, le procédé comportant les étapes consistant à : 25

détecter la vitesse du moteur (1); détecter la pression de fluide à l'intérieur de l'accumulateur (6); détecter la demande de puissance du véhicule; modifier la cylindrée du moteur fluidique (4) en réponse à la demande de puissance détectée et à la pression de fluide détectée pour satisfaire à la demande de puissance et pour maintenir au moins une pression minimale avec l'accumulateur (6); et commander la cylindrée de la pompe (2), en réponse à la pression détectée, pour maintenir la vitesse du moteur détectée dans une plage pré-déterminée sur la base du rendement du moteur. 30

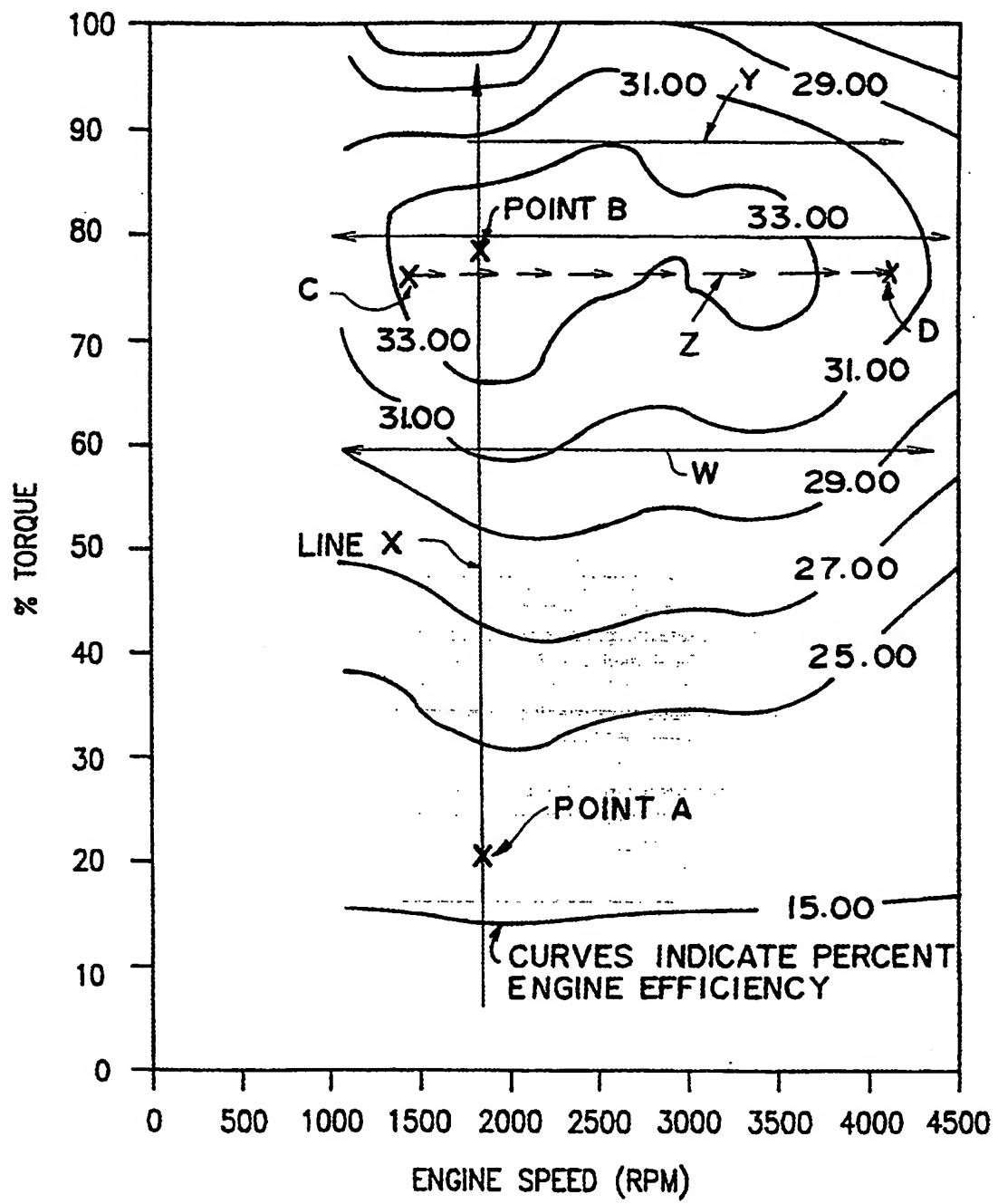


FIG. 1

FIG. 2

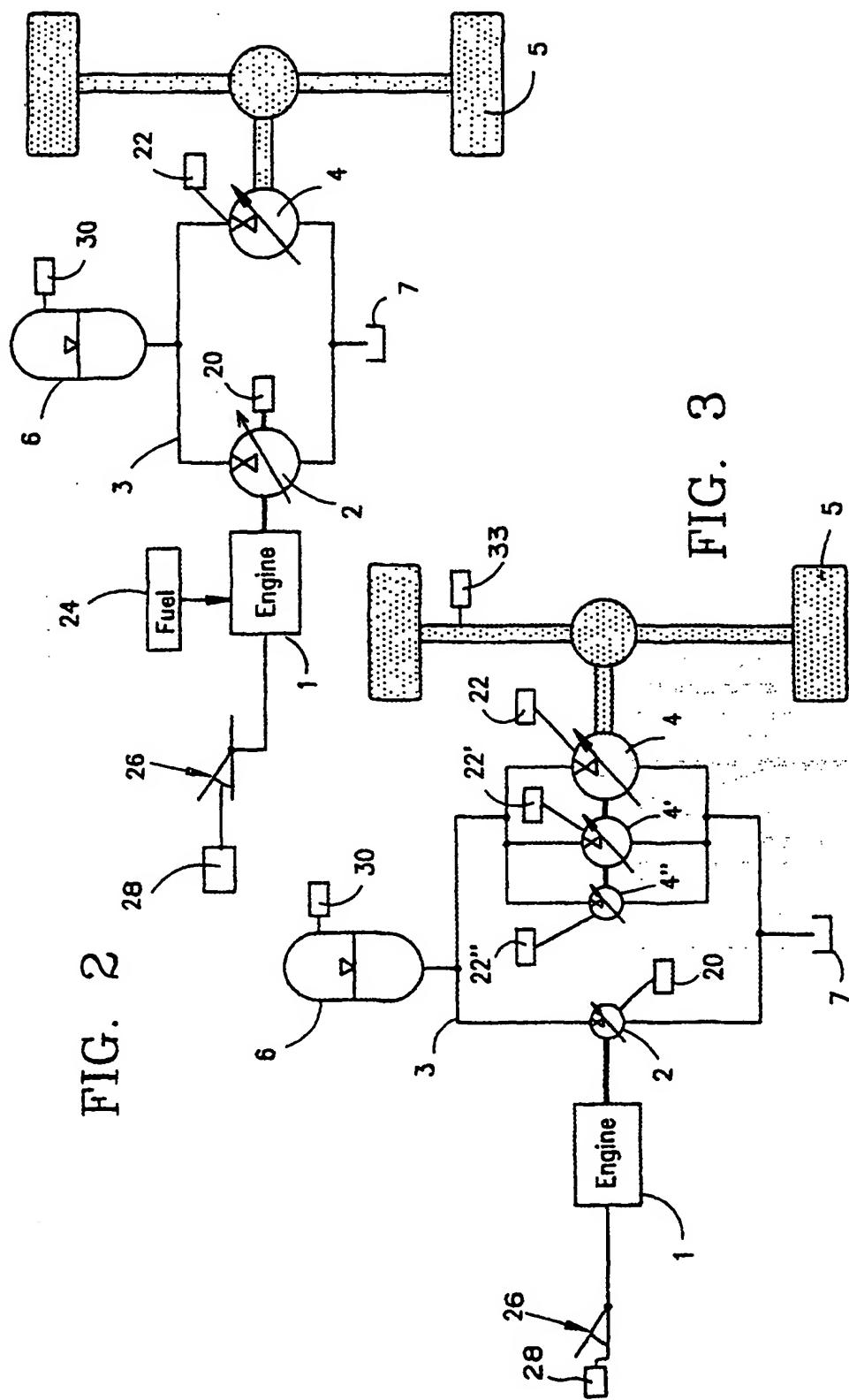


FIG. 3

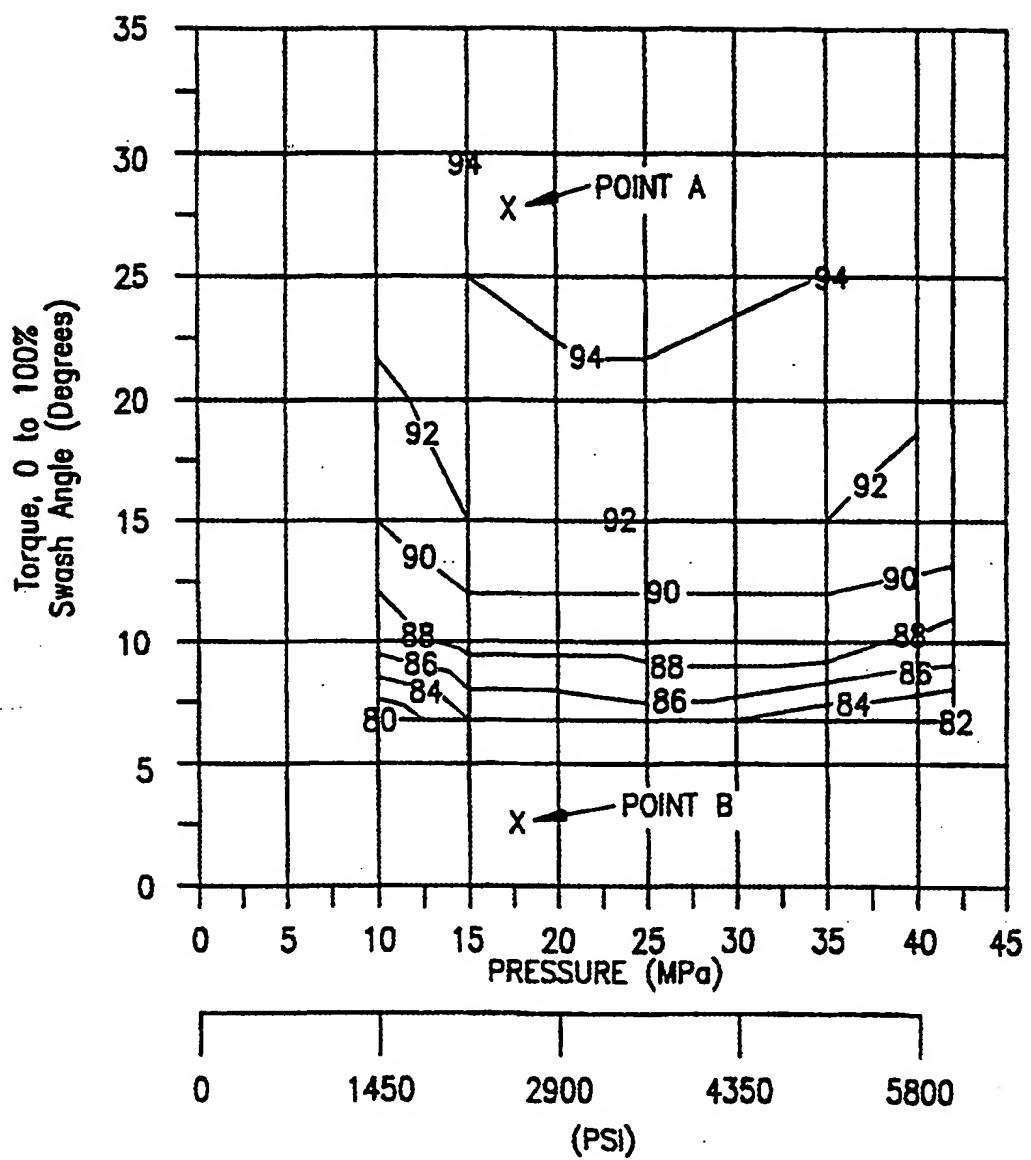
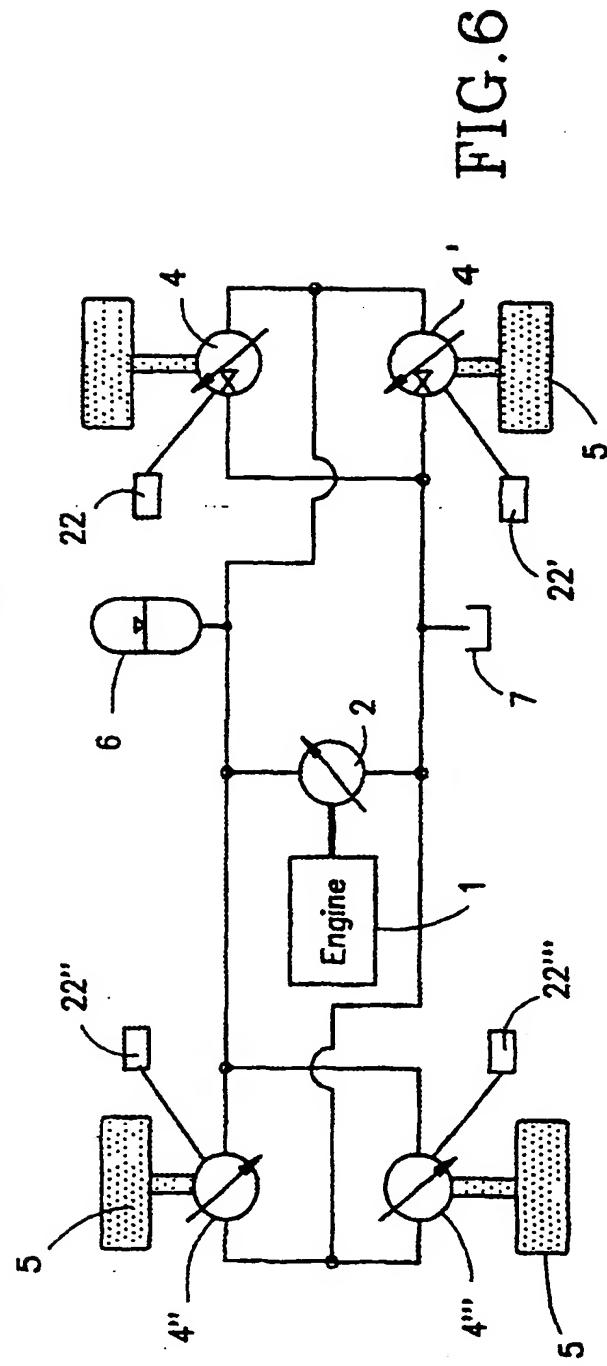
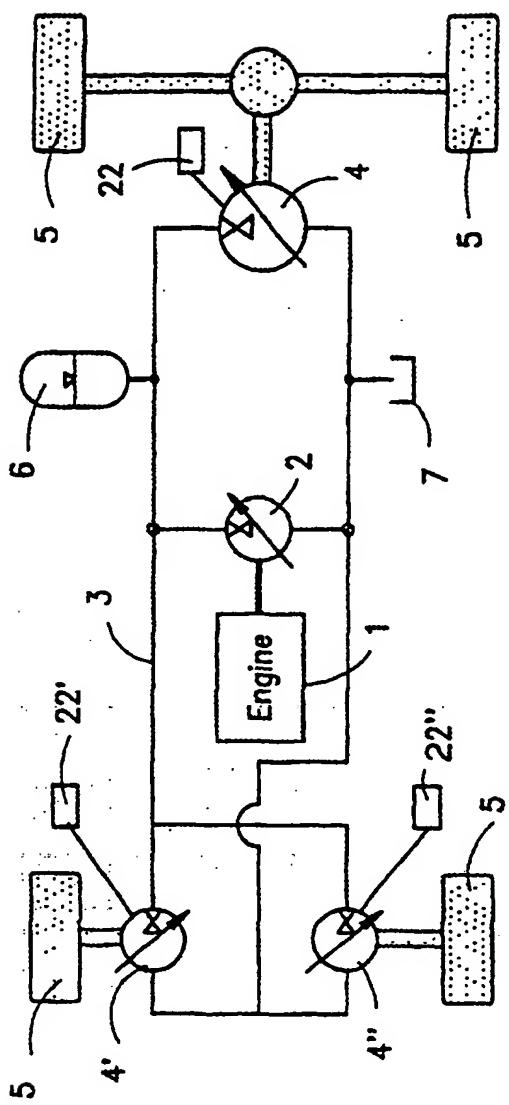
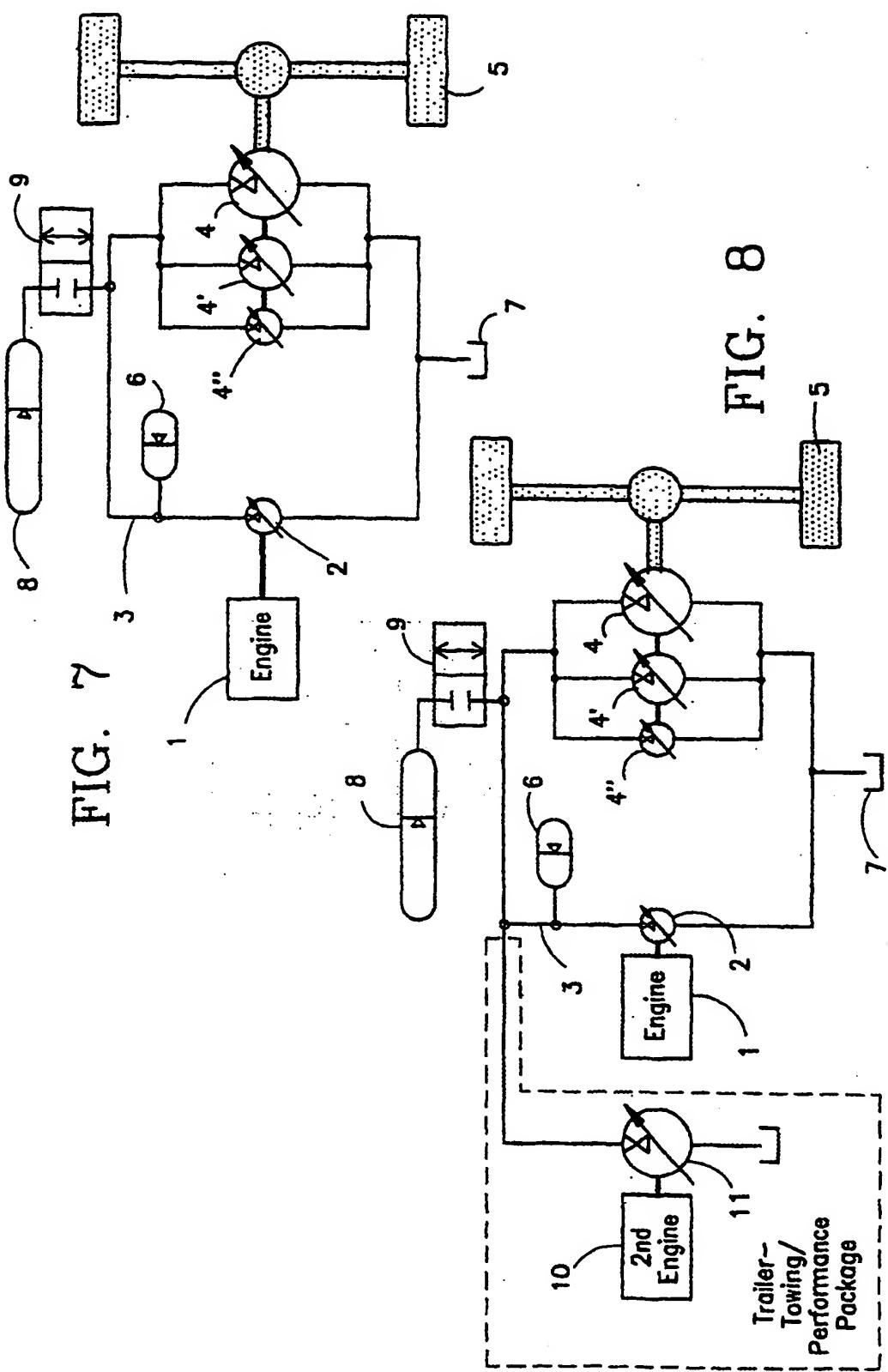


FIG. 4





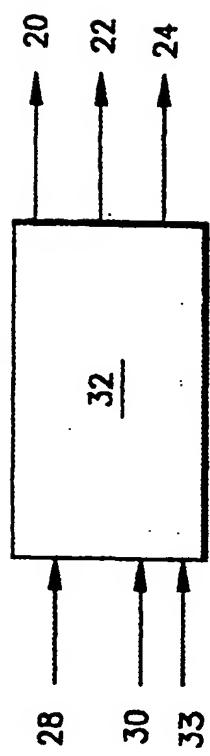


FIG. 9

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